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ORIGINAL

Immediate Effects of Joint Mobilization Techniques on Clinical Measures in Individuals with CAI

Byong Hun Kim[1], Chang Young Kim[1], Tae Kyu Kang[1], Young Jae Cho[2], Sae Yong Lee[1]

[1]Department of Physical Education, Yonsei Institute of Sports Science and Exercise Medicine (YISSEM), Yonsei University, Seoul, South Korea
[2]SOL Hospital, Seoul, South Korea

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Corresponding Author
Sae Yong Lee
Department of Physical Education, Yonsei Institute of Sports Science and Exercise Medicine (YISSEM), Yonsei University, Sports Science Complex 310, 03722, South Korea
Tel : +82-2-2123-6189
Fax : +82-2-2123-8375
Email : sylee1@yonsei.ac.kr

Objective: Epidemiological research shows that 47 to 73% of athletes suffer from recurrent ankle sprains. Joint mobilization techniques (JMT) implemented in correcting may be beneficial in the management of ankle injuries. The purpose of this study is to examine the immediate JM on ankle complex as clinical measures in individuals with chronic ankle instability (CAI) through intervention.

Method: Thirteen subjects with CAI (8 males and 5 females) participated in this study. Each subject tried total four alignments (Navicular drop test: NDT, Standing rearfoot angle: SRA, Tibia torsion: TT, and dorsiflexion range of motion: DFROM). The participants were performed the 10 meter shuttle run after JMT for post-task. Finally, it was tried to compare between pre-post tasks after shuttle run.

Results: SRA and DFROM after intervention showed significant differences. SRA (p=.026), and DFROM (p=.034).

Conclusion: We concluded that the JMT has resulted in improvement in SRA, DFROM. Increased DFROM and varus shapes of foot would be closed kinetic chain, indicating that reduce the risk factors of ankle sprain. Future study needs to be conducted in order to measure the effects of prolonged intervention of JMT.

Keywords: CAI, SRA, NDT, TT, DF range of motion

INTRODUCTION

The acute ankle sprain is one of the most common injuries in the lower extremity. Epidemiological research studies show that 47 to 73% of athletes suffer from recurrent sprains (Osborne & Rizzo, 2003). More than 23,000 ankle sprains are estimated to occur each day in the United States (van Rijn et al., 2008). Even more disconcerting than the initial ankle sprain is that the large percentage of patients who suffer from repetitive ankle sprains develop CAI, which is defined as the condition of recurrent ankle sprains (Hiller et al., 2011)

When an ankle sprain occurs, the anterior talofibular ligament (ATFL) is reported to be the weakest ligament that is affected. The injuries to ATFL, if left untreated, may cause to develop injuries to other soft-tissues such as the calcaneofibular ligament (CFL). These ligaments, once damaged, lead to mechanical laxity. The stretched ligaments may not return to their normal status except through a surgical method. The failure of treatment may further induce hypermobility (Hubbard & Hicks-Little, 2008). Not only ligament damages, CAI without proper treatment also develops articular deformities of the ankle joint along with increased risk of osteoarthritis (Valderrabano, Hintermann, Horisberger, & Fung, 2006). Another problem that may be caused by the lateral ankle sprains is restricted DF. Many people with CAI are found to have deficit of dorsiflexion (DF), which is not a surprising fact. This may cause open-pack position which may increase the risk of damage to the ankle (Abidi, Dhawan, Gruen, Vogt, & Conti, 1998). For this reason, the restricted DF that causes excessive supination moments leads to increased occurrences of repetitive ankle sprains in daily life (Drewes, McKeon, Kerrigan, Hertel, 2009). Thus, many rehabilitation methods of ankle sprains are being reported. Many manual therapy interventions including JMT have been examined to deal with the mechanical alterations associated with CAI (Vicenzino, Branjerdporn, Teys, & Jordan, 2006)). It has been reported that an injured ankle may be treated with JMT. Particularly, JMT has been proved to be effective in that it immediately restores ankle mobility in DF and plantarflexion (PF) in elderly patients (Chevutschi, D'houwt, Pardessus, & Thevenon, 2015). Previous research stated that have reported that acute ankle injury patients can be helped with posterior talocrural JM in a timely treatment of DF of motion and return to work (Green, Refshauge, Crosbie, & Adams, 2001). A single joint-mobilization treatment is an effective treatment of DF range of motion (ROM) with CAI. Also, some manual therapy techniques based on talocrural JM have been proven to effectively work on this kind of stimuli in DFROM and arthrokinematic improvement (Hoch et al., 2012). For those with CAI, JM at the talocrural joint typically focuses on gliding the talus posteriorly in the ankle mortise to increase DFROM (Hoch et al.,

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2012). The subtalar JM typically focuses on calcaneal eversion during subtalar joint movement. In this point of view, JTM is useful to help restore the pronation of the foot. Previous studies have demonstrated that JM requires refinement for improvement of rehabilitation development. Passive JMs consist of gentle oscillating movements of the articular surfaces that create the movement of the ankle joint by a means other than the musclo-tendinous units that normally act on those particular segments (Pruyn et al., 2013). Additionally, gastrocnemius and soleus muscle tightness has been commonly reported to be one of contributing factors of increasing DFROM. The JM can possibly restore the normal joint's ROM and relieve the negative effects in afferent signals as well as the proprioceptive alterations. Therefore, JMT can be implemented in correcting joint dysfunctions, which may be beneficial in the management of ankle injuries. The purpose of the present study is to evaluate the immediate effects of JMT of talocrural and subtalar joints on ankle mobility in CAI patients.

METHODS

1. Participants

The data from 13 participants with chronic ankle sprain were included in this study.

Table 1 displays the descriptive demographic, dependent variables measurements averaged across all participants. Overall there were 8 males and 5 females included in this study with a mean age of 28 years. BMI averages 24.9. All included participants reported unilateral (R/Ankle) CAI although there was no limitation bilateral or unilateral CAI.

Table 1. Mean (Standard Deviation: SD) and Range of demographics & data

	Mean (SD)	Range
Gender (Male/Female)	8/5	
Age (years)	28.5±6.3	21-44
Height (cm)	168.8±12.3	146.3-192.2
Weight (kg)	71.7±15.2	44.6-90
BMI	24.9±3.2	17.75-30.13
VAS	1.3±1.2	0-4
FAAM (%)	86.9±8.5	0.63-1.0
FAMM-S (%)	84.1±16.8	0.47-1.0
# Sprains (lifetime)	5.2±2.9	3-8
How long (months)	27.0±32.2	22-38

VAS = visual analog scale

In order to achieve the purpose of the study, a selection of CAI patients of 8 males and 5 females who met the standard was conducted. The experimental motive and procedures was communicated verbally and written informed consent below was also taken prior to the experiment. Inclusion and exclusion criteria was based on the relevant research performed by Quick FAAM questionnaire.

2. Procedure

The human experimentation has been approved by the LIFE University Institutional Review Board.

Figure 1 below shows procedures, Initially, subjects were given an opportunity to ask questions regarding the research and procedures prior to giving their consent. The subjects were asked to fill out a short questionnaire indicating their history of ankle injury. Each subject tried total four alignments (NDT, SRA, TT, and Passive DFROM). The subjects were received a Maitland Grade IV oscillatory ankle JM. The participants were performed the 10 meter shuttle run after JM technique for post-task. Finally, it was tried to compare between pre-post tasks after shuttle run (Figure 8).

Order	Variables
1	Quick FAAM consent form
2	Pre-intervention measurement Clinical measure 1) NDT 2) TT 3) SRA 4) DFROM
3	JMT (Maitland Grade IV)
4	Active Running (10 m X 2)
5	Post-intervention measurement Clinical measure 1) NDT 2) TT 3) SRA 4) DFROM
6	Data processing
7	Result

Figure 1. Experimental design

3. Measurement methods

All procedures below. Initially, subjects were given an opportunity to ask questions regarding the research and procedures prior to giving their consent. The subjects were asked to fill out a short questionnaire indicating their history of ankle injury.

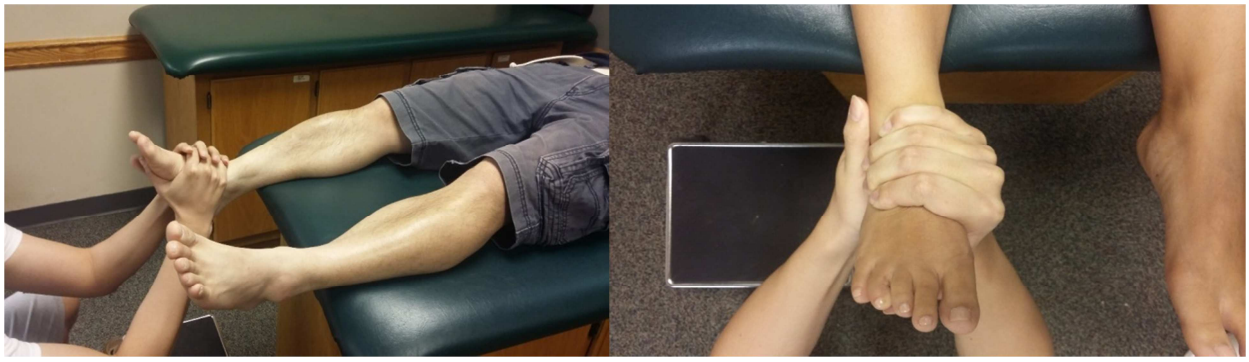

Figure 2. Maitland Grade Ⅳ oscillatory anterior to posterior ankle JMT

1) JMT

The subjects were receive a Maitland Grade Ⅳ oscillatory ankle JMT. The JMT performed by a Certified Athletic Trainer with five years of clinical experience. Subjects were seated on a treatment-table with the knee extended and ankle positioned off the edge of the table in a neutral position in Figure 2.

The clinician stabilized the distal aspect of the lower leg with one hand and a c-shape formed by the opposite hand were placed just below the medial and lateral malleoli contacting the anterior talus. This hand performed the JMT by gliding the talus posteriorly. Three 60 second anterior to posterior JMT of the talus applied by the therapist with a minute rest in between sets. The JMT applied with low amplitude, one-second rhythmic oscillations at the joint's physiologic end range.

2) Navicular drop test

With the patient sitting comfortably (feet are on the floor, but are non-weight bearing), palpate the medial aspect of each foot and find the navicular prominence. This was the most prominent bony landmark found inferior and somewhat anterior to the patient's medial malleolus. Using a pen, make a mark on the patient's skin at the point of the navicular prominence. Place the measuring device against the medial arch of the foot and mark at the level of the navicular prominence. The Subtalar joint neutral position was founded by finding the point where the medial and lateral aspect of the talar head are equally palpable (Shultz, Nguyen, & Levine, 2009). The participant stands in a normal posture with equal weight bearing on both feet and then the navicular height re-measured. The height difference of weight bearing navicular height is subtracted from non-weight bearing navicular height and the difference were recorded as the navicular drop (Figure 3).

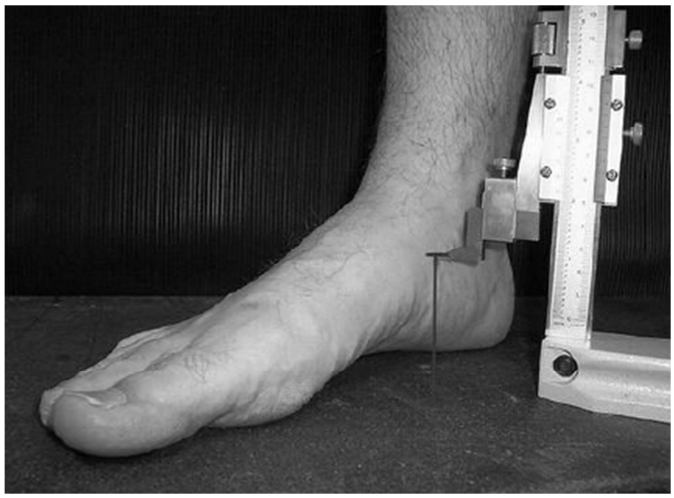

Figure 3. Navicular drop test measurement

3) Tibia torsion

Tibia torsion were measured while participant lying supine with those epicondyles of the knee equally positioned parallel to the horizontal surface (Figure 4). The angle between the imaginary vertical line and the bi-malleolar axis measured and recorded as tibial torsion (Shultz et al., 2009).

Figure 4. Tibial torsion measurement

4) Standing rearfoot angle

Rearfoot angle measured using three anatomical landmarks marked by a pen: 1) the posterior calcaneal tuberosity; 2) the second point above the calcaneus; and, 3) the lower third of the leg (Ribeiro et al., 2011) (Figure 5). The participant was asked to march in place three (3) times and put both feet shoulder width apart and toes facing straight forward. The participant was instructed to evenly distribute their weight on each foot. The angle between those three landmarks recorded as a rearfoot angle (Figure 6).

Figure 5. Anatomical landmarks for rearfoot angle measurement

Figure 6. Standing rearfoot angle measurement

5) Dorsiflexion range of motion

Flexion the knee to relax the gastrocnemius and align the plantar surface of the foot perpendicular to the axis of the leg. This is zero degrees starting position. The ankle should be able to dorsiflex at least 20 degrees (Figure 7).

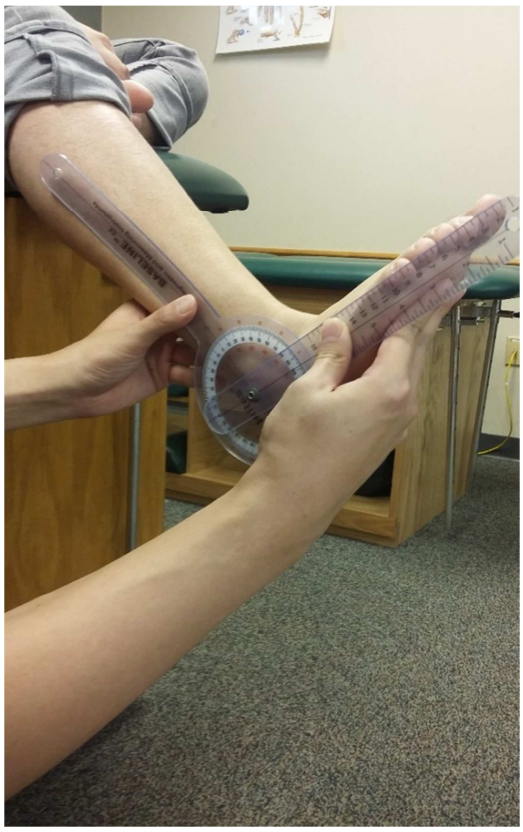

Figure 7. Dorsiflexion range of motion

6) Active running

Mark two lines 10 meters apart using marking tape or cones. The two blacks are placed on the line opposite the line they are going to start at. The participants were performed the 10 m shuttle run after JMT for post intervention

4. Data analysis

All data were analyzed via SPSS for Windows version 22.0 statistical program (IBM Corp., Armonk, NY, USA). We used descriptive statistics to examine the general characteristics of the participants and pre- and post-intervention the lower extremity alignments and JMT, and used dependent *t*-test examine the significance of the differences between pre- and post-intervention ankle characteristics. The significance level α was set to 0.05.

Figure 8. 10-m shuttle run

RESULTS

1) Analysis of lower extremity alignment between pre and post intervention.

The dependent variables, means, standard deviations and standard error for pre-post assessments are provided in Table 2.

2) The dependent *t*-test was performed to determine whether effect in clinical measures or not after JM. The statistics model revealed two clinical variables that had significant differences in Table 3.

Table 3. Absolute change scores of all dependent variables for JM

DF	Mean	SD	*t*	Sig. (2-tailed)
Paired navicular pre-post	.12	2.16	.212	.836
Paired tibia pre-post	1.22	4.23	1.045	.317
Paired rearfoot pre-post	-1.38	1.96	-2.546	.026
Paired DFROM pre-post	-1.23	1.85	-2.399	.034

For SRA (Mean = -1.38, SD = 1.96, t = -2.546, p = .026) and DFROM (Mean = -1.23, SD = 1.85, t = -2.399, p = .034 Table 3)

DISCUSSION

This study has been conducted to evaluate the immediate effects of JMT on clinical measures (NDT, TT, SRA and DFROM ankle PROM) of the lower extremities in individuals with CAI through pre and post intervention. Grade IV anterior-posterior talar glide JM has now shown any statistically significant improvement in the NDT or TT. However, SRA and DFROM Ankle PROM have a significant difference, which demonstrates that the JMT may provide benefits of improvement in DFROM, SRA, and pain in patients with CAI. The results have demonstrated that the ankle JMT play a crucial role in reducing the risk factors in CAI. There have been no statistically significant differences in the pre-post intervention when evaluating CAI. Previous studies have reported that the JMT may reduce sway area, sway path length, and sway max velocity while improving balance for individuals with supination of the foot. Therefore, the JMT could be used as a clinical treatment method

Table 2. Summary of dependent *t*-test analysis for variables (N=13)

	Pre				Post			
	Mean	N	SD	SEM	Mean	N	SD	SEM
Dependent variables								
NDT	7.92	13	3.92	1.08	7.79	13	2.85	.79
TT	19.66	13	4.97	1.37	18.43	13	5.29	1.46
SRA	-1.82	13	2.49	.69	-.4354	13	2.85	.79
DFROM	17.28	13	4.20	1.16	18.51	13	4.57	1.26

NDT: NDT, TT: TT, SRA: SRA, DFROM: DF Range of Motion

to increase balance with supinated foot patients (Gong, Ma, & Kim, 2009). In contrast to previous study, the navicular drop might be the most appropriate technique for the clinical assessment of foot pronation (Menz, 1998). Hyper-pronation or supination may have a direct correlation with ankle sprain as functional biomechanical aspects (Kannus, 1992). According to the study had no direct effect on ankle sprains, previous studies suggest that navicular position may provide useful information of the overall foot complex. Also, JMT may stimulate sensory receptors and result in an increase in an afferent activity along with the improvement of neuromuscular function of the joint stabilizing around ankle muscles, tendons and joints (Grindstaff et al., 2011). In addition, the NDT is a good predictor for assessment of the ankle. However, it has not been used in this study. Therefore, further studies are required to properly evaluate the effect of JM on muscle activation. There have been no statistically significant differences in the pre- and post- tests. Although TT is not directly related to ankle sprain, a previous study has suggested that the external TT may provide useful information on the human kinetic chain (Clementz, 1989). TT may be related to gait patterns. Orthotics and gait plates may also be utilized to help to move the foot towards external rotation during gait (Schwartz & Lakin, 2003). They are also beneficial in preventing abnormal compensation, which could put stress on the arch. However, in our study, there are no significant differences between arch issues and TT angle. There are statically significant pre and post in the changes after JM techniques have been used. Recurrent ankle sprain may have possibilities of soft tissues injuries because of lateral ligamentous damage caused by excessive supination or inversion of the rearfoot angle (Hertel, 2002). Also, previous study stated that the CFL ligament restricts excessive inversion and internal rotation of the reafoot and is taut during DF. They have demonstrated that it can be assessed by determining the amount of talar tilt when inverting the rearfoot when the talocrural joint is pressed by external forces (Hertel, 2002). However, the rearfoot function is more complicated than a simple hinge model. There were lots of studies of increase in DFROM after JM. The JM techniques could improve DFROM in individuals with CAI. Previous study has reported that a Maitland Grade IV anterior to posterior JM to the ankle improved ankle DF (Terada, Pietrosimone, & Gribble, 2013). One research has stated that a 5-week intervention of talocrural and subtalar JMs in combination with therapeutic exercises produced greater DFROM gains and functional recovery than therapeutic exercise alone has been done (Landrum, Kelln, Parente, Ingersoll, & Hertel, 2008). However, other article have stated that individuals with CAI have restored full ankle DFROM without special techniques, and suggested that this restoration of ankle DFROM may due to flexibility of calf muscles complex and hypermobility of other joints (Denegar & Miller III, 2002). As aforementioned, a single application of JM has improved DFROM in individuals with ankle pathologies (Landrum et al., 2008). In our study, we have conducted pre-post intervention in individuals with CAI, but we have not established any known ankle pathologies. Previous research demonstrated that have reported that JM of the talus using a gentle force resulted in greater improvement in DFROM and return to normal gait pattern in participants (Green, Refshauge, Crosbie, & Adams, 2001). Collins' study have demonstrated that immediate improvements in DFROM in subacute ankle sprain patients receiving a single application of mobilizations with movement (Collins, Teys, & Vicenzino, 2004). Also, Vicenzino have reported that similar findings in patients suffering from recurrent ankle sprains (Vicenzino et al., 2006).

CONCLUSION

In conclusion, a single dose of a Maitland Grade IV anterior to posterior talar glide JM has resulted in statistically significant improvement in SRA, Ankle DFROM. However, some of the outcome measures had not shown any statistical differences, indicating that JMs may provide potential clinical benefits for the improvement in SRA, Ankle DFROM in individuals with CAI. In other words, if SRA has more of varus shapes, increased DFROM would be closed kinetic chain, indicating that reduce the risk factors of ankle sprain. Future research needs to be conducted in order to measure the effects of prolonged intervention of JMT.

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REFERENCES

Abidi, N. A., Dhawan, S., Gruen, G. S., Vogt, M. T. & Conti, S. F. (1998). Wound-healing risk factors after open reduction and internal fixation of calcaneal fractures. *Foot & Ankle International*, *19*(12), 856-861.

Chevutschi, A., D'houwt, J., Pardessus, V. & Thevenon, A. (2015). Immediate Effects of Talocrural and Subtalar Joint Mobilization on Balance in the Elderly. *Physiotherapy Research International*, *20*(1), 1-8.

Clementz, B.-G. (1989). Assessment of tibial torsion and rotational deformity with a new fluoroscopic technique. *Clinical Orthopaedics and Related Research*, *245*, 199-209.

Collins, N., Teys, P. & Vicenzino, B. (2004). The initial effects of a Mulligan's mobilization with movement technique on dorsiflexion and pain in subacute ankle sprains. *Manual Therapy*, *9*(2), 77-82. doi: 10.1016/S1356-689x(03)00101-2

Denegar, C. R. & Miller III, S. J. (2002). Can chronic ankle instability be prevented? Rethinking management of lateral ankle sprains. *Journal of Athletic Training*, *37*(4), 430.

Gong, W.-T., Ma, S.-Y. & Kim, T.-H. (2009). The effect of ankle joint mobilization technique on equilibrium ability in the individuals with supinated foot. *Journal of the Korean Data and Information Science Society*, *20*(3), 527-539.

Green, T., Refshauge, K., Crosbie, J. & Adams, R. (2001). A randomized controlled trial of a passive accessory joint mobilization on acute ankle inversion sprains. *Physical Therapy*, *81*(4), 984-994.

Grindstaff, T. L., Beazell, J. R., Sauer, L. D., Magrum, E. M., Ingersoll, C. D. & Hertel, J. (2011). Immediate effects of a tibiofibular joint manipulation on lower extremity H-reflex measurements in individuals with chronic ankle instability. *Journal of Electromyography and Kinesiology*, *21*(4), 652-658.

Hertel, J. (2002). Functional anatomy, pathomechanics, and pathophysiology of lateral ankle instability. *Journal of Athletic Training*, *37*(4), 364-375.

Hiller, C. E., Ightingale, E. J. N., Lin, C. W. C., Coughlan, G. F., Caulfield, B. & Delahunt, E. (2011). Characteristics of people with recurrent ankle sprains: a systematic review with meta-analysis. *British Journal of Sports Medicine*, *45*(8), 660-672. doi: 10.1136/bjsm.2010.077404

Hoch, M. C., Andreatta, R. D., Mullineaux, D. R., English, R. A., Medina McKeon, J. M., Mattacola, C. G. & McKeon, P. O. (2012). Two-week joint mobilization intervention improves self-reported function, range of motion, and dynamic balance in those with chronic ankle instability. *Journal of Orthopaedic Research*, *30*(11), 1798-1804.

Hubbard, T. J. & Hicks-Little, C. A. (2008). Ankle ligament healing after an acute ankle sprain: an evidence-based approach. *Journal of Athletic Training*, *43*(5), 523-529.

Kannus, V. (1992). Evaluation of abnormal biomechanics of the foot and ankle in athletes. *British Journal of Sports Mmedicine*, *26*(2), 83-89.

Landrum, E. L., Kelln, B. M., Parente, W. R., Ingersoll, C. D. & Hertel, J. (2008). Immediate effects of anterior-to-posterior talocrural joint mobilization after prolonged ankle immobilization: a preliminary study. *Journal of Manual & Manipulative Therapy*, *16*(2), 100-105.

Menz, H. B. (1998). Alternative techniques for the clinical assessment of foot pronation. *Journal of the American Podiatric Medical Association*, *88*(3), 119-129.

Osborne, M. D. & Rizzo, T. D. (2003). Prevention and treatment of ankle sprain in athletes. *Sports Medicine*, *33*(15), 1145-1150.

Pruyn, E. C., Watsford, M. L., Murphy, A. J., Pine, M. J., Spurrs, R. W., Cameron, M. L. & Johnston, R. J. (2013). Seasonal variation of leg stiffness in professional Australian rules footballers. *The Journal of Strength & Conditioning Research*, *27*(7), 1775-1779.

Ribeiro, A. P., Trombini-Souza, F., Tessutti, V., Rodrigues Lima, F., Sacco, I. D. C. N. & João, S. M. A. (2011). Rearfoot alignment and medial longitudinal arch configurations of runners with symptoms and histories of plantar fasciitis. *Clinics*, *66*(6), 1027-1033.

Schwartz, M. & Lakin, G. (2003). The effect of tibial torsion on the dynamic function of the soleus during gait. *Gait & Posture*, *17*(2), 113-118.

Shultz, S. J., Nguyen, A.-D. & Levine, B. J. (2009). The relationship between lower extremity alignment characteristics and anterior knee joint laxity. *Sports Health*, *1*(1), 54-60.

Terada, M., Pietrosimone, B. G. & Gribble, P. A. (2013). Therapeutic interventions for increasing ankle dorsiflexion after ankle sprain: a systematic review. *Journal of Athletic Training*, *48*(5), 696-709.

Valderrabano, V., Hintermann, B., Horisberger, M. & Fung, T. S. (2006). Ligamentous posttraumatic ankle osteoarthritis. *The American Journal of Sports Medicine*, *34*(4), 612-620.

van Rijn, R. M., Van Os, A. G., Bernsen, R. M., Luijsterburg, P. A., Koes, B. W. & Bierma-Zeinstra, S. M. (2008). What is the clinical course of acute ankle sprains? A systematic literature review. *The American Journal of Medicine*, *121*(4), 324-331. e327.

Vicenzino, B., Branjerdporn, M., Teys, P. & Jordan, K. (2006). Initial changes in posterior talar glide and dorsiflexion of the ankle after mobilization with movement in individuals with recurrent ankle sprain. *Journal of Orthopaedic & Sports Physical Therapy*, *36*(7), 464-471.